Space Weather Technical Forecast

Issued on Monday 4 November 2024 at 13:08 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: Moderate to High solar activity with M-flares expected, and a slight chance of X-class flares.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity was moderate to high with multiple M-flares over the past 24hrs, the largest of which was an M3.8 at 04/0141UTC from AR3883 in the southeast disc. There are twelve active sunspot regions on the visible disc, with one new unnumbered region. AR3883 in the southeast has produced multiple M-class solar flares and contains at least two delta spots, with the leading delta spot being especially complex. Spots AR3869-AR3875 are now approaching the western limb and as such are becoming difficult to analyse. AR3878 has now rotated into the western hemisphere, and maintains a weak delta spot. AR3881 is now around south-centre disc, and appears to have developed a small delta spot within its intermediate spots. Newly numbered regions coming over the eastern limb appear to have some significant magnetic looping in SDO 171 imagery, but will have to rotate further onto the disc for a proper analysis to be undertaken. The other spots on the disc have remained fairly stable, or are showing signs of decline.

A CME was observed off the E limb in association with the M3.8 flare from AR3883, with initial assessment suggesting the CME will miss behind Earths orbit. Gaps in available imagery however mean this is currently lower confidence.

Solar Wind / Geomagnetic Activity: Solar winds as measured at L1 by ACE/DSCOVR were at slightly elevated levels throughout, generally between 420-470km/s. Density was initially below average, but became above average from around 03/1700UTC. The Interplanetary Magnetic Field (IMF), Bt, was predominantly weak, around 5-8nT, but did fall to as low as 2nT. The north-south component, Bz, was initially positive (northward directed) until 03/1745UTC, from at which point it became weakly negative (southward directed), ranging through the whole period between +7nT and -6nT. Phi angle was variable but favoured a negative direction (towards the Sun) until around 03/1941UTC, at which point it became persistently positive (away from the Sun). Geomagnetic activity was mainly Quiet to Unsettled (Kp1-3), but became Active (Kp4) between 03/2100-04/0300UTC and saw a G1/Minor Geomagnetic Storm (Kp5) interval between 04/0300-0600UTC, before becoming Quiet once again.

Energetic Particles / Solar Radiation: High energy proton flux observed by GOES18 was elevated but remained below S1 Minor Radiation Storm level throughout, continuing to show a gradual decline. High energy electron flux (greater than 2MeV) observed by GOES16 was at Background.

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The associated 24-hour fluence was well below the Active threshold, with 1.22e6 integrated flux observed at 04/0001UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Moderate to High activity is expected to continue, with occasional M-class flares expected and a slight chance of isolated X-class flares.

Solar Wind / Geomagnetic Activity: Connection to coronal hole fast winds is ongoing, albeit weakly, with enhancement expected to continue through Day 1 into Day 2 (04-05 Nov). Generally Quiet to Unsettled geomagnetic activity is expected initially, with a chance of Active and a slight chance of G1/Minor Geomagnetic Storm intervals. Activity then expected to decline to Quiet by Day 3 (06 Nov), although confidence in this is lower than usual.

Energetic Particles / Solar Radiation: The high energy proton flux at GOES-18 is now below the S1 Moderate Radiation Storm level, and continuing to slowly decline. However, any further notable flares bring a persistent chance for further enhancement during the period. The high energy electron flux is expected to be Background to Moderate, with the associated fluence forecast to persist below Active levels.

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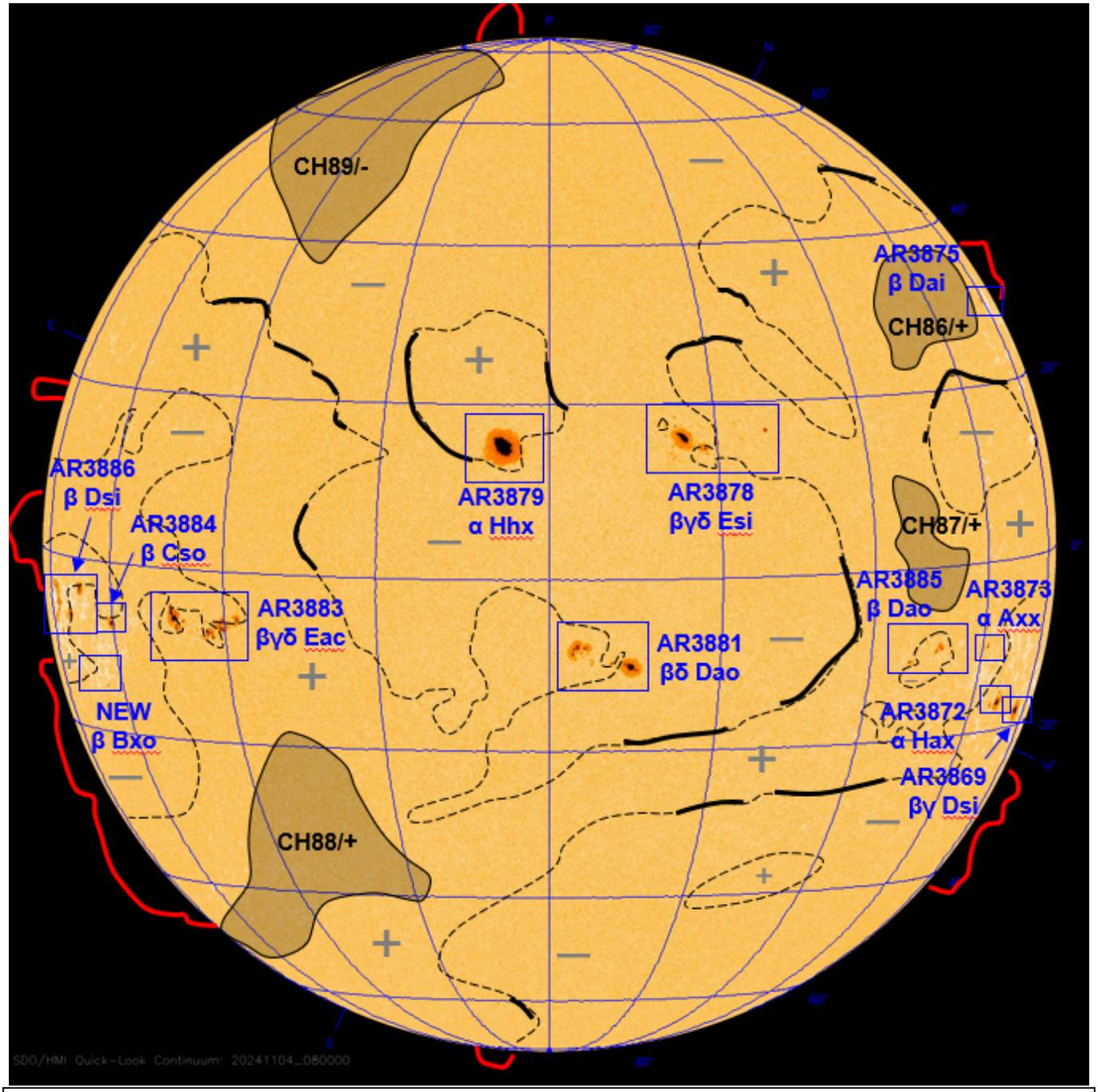
Figure 1: Solar Synoptic Map valid 04/0800UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms

A CME which left the Sun during 31 Oct was forecast to give a glancing blow to Earth earlier today 1 (04 Nov), but given the low confidence of this forecast and no indication of its arrival as of yet, this has probably missed Earths orbit. A CME was observed off the E limb in association with the M3.8 flare from AR3883 at 04/0141UTC, with an associated Type II radio emission of 307km/s. Analysis remains difficult due to coronagraph imagery gaps, but an initial assessment has the bulk of the CME passing behind Earths orbit, however a glancing blow on Day 3 (06 Nov) can't be ruled out. This is lower confidence currently.

The near Earth environment continues to be weakly enhanced with winds currently at slightly elevated levels, likely as a result of a weak connection to coronal hole CH87/+, or perhaps CH86/+. A stronger connection cannot be ruled out, perhaps raising solar winds to elevated levels, although this is lower confidence. MOSWOC ENLIL model hasn't resolved these coronal hole fast winds, and as such has Earth in more background solar winds. The increase in solar winds later in the Enlil model run (07 Nov onwards) is also deemed spurious, with no obvious source region for this increase in solar winds.

Generally Quiet to Unsettled geomagnetic activity is expected through Days 1-2 (04-05 Nov), with a chance of Active and a slight chance of G1/Minor Geomagnetic Storm intervals given the ongoing weak HSS influence. Any late arrival of the glancing CME would also add to any enhancement. Activity then expected to decline to Quiet levels by Day 3 (06 Nov) although confidence in this is slightly lower than usual due to uncertainties in CME analysis.

Geomagnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	Yes	20	10	5	1
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

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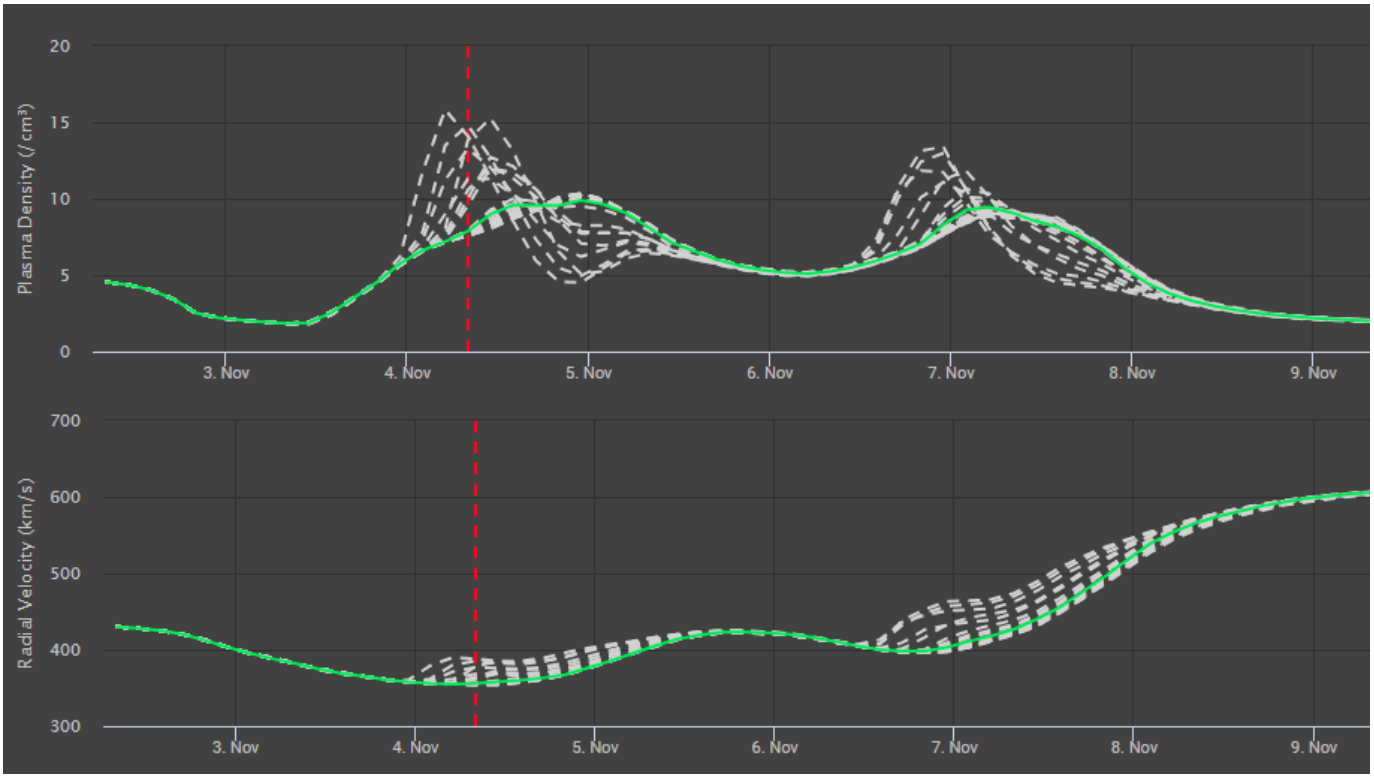
Figure 2: MOSWOC Ensemble model, showing a spread of possible CME arrival times. The arrival on 04 Nov is due to the forecast glancing CME, but this has likely missed Earth. Later on 06 Nov shows a possible glance from the CME from early on 04 Nov, however this is low confidence.



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Radio Blackouts - X-Ray Flares

There are twelve active sunspot regions on the visible disc, with one unnumbered region. AR3883 in the southeast has produced multiple M-class solar flares and contains at least two delta spots, with the forward delta spot being especially complex. AR3878 contains a small delta spot in its trailing region, although it appears to have weakened in recent hours. AR3881 is now to the west of centre disc and appears to have developed a small delta spot within one of its intermediate spots, but has remained quiet. Spots AR3869-AR3875 are now approaching or rotating around the western limb and as such are becoming difficult to analyse. AR3886 on the eastern limb has been numbered, currently appearing to be a large region with a number of spots. The regions that have recently appeared from over eastern limb appear to be located within the same area of plage, with significant magnetic looping visible in SDO 171 imagery across this area. These regions will continue to be reanalysed as they rotate further into view. The other spots on the disc have remained fairly stable or are showing signs of decline.

Solar activity was moderate to high with multiple M-flares over the past 24hrs, the largest of which was an M3.8 peaking at 04/0142 UTC from AR3883 in the southeast disc. Moderate to High activity is expected to continue, with further M-class flares expected and a slight chance of isolated X-class flares, with AR3883 currently the most likely source for significant flares.

X-Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 (M Class)	Yes	80	80	80	80
Very Active	R3-R5 (X Class)	No	20	20	20	20

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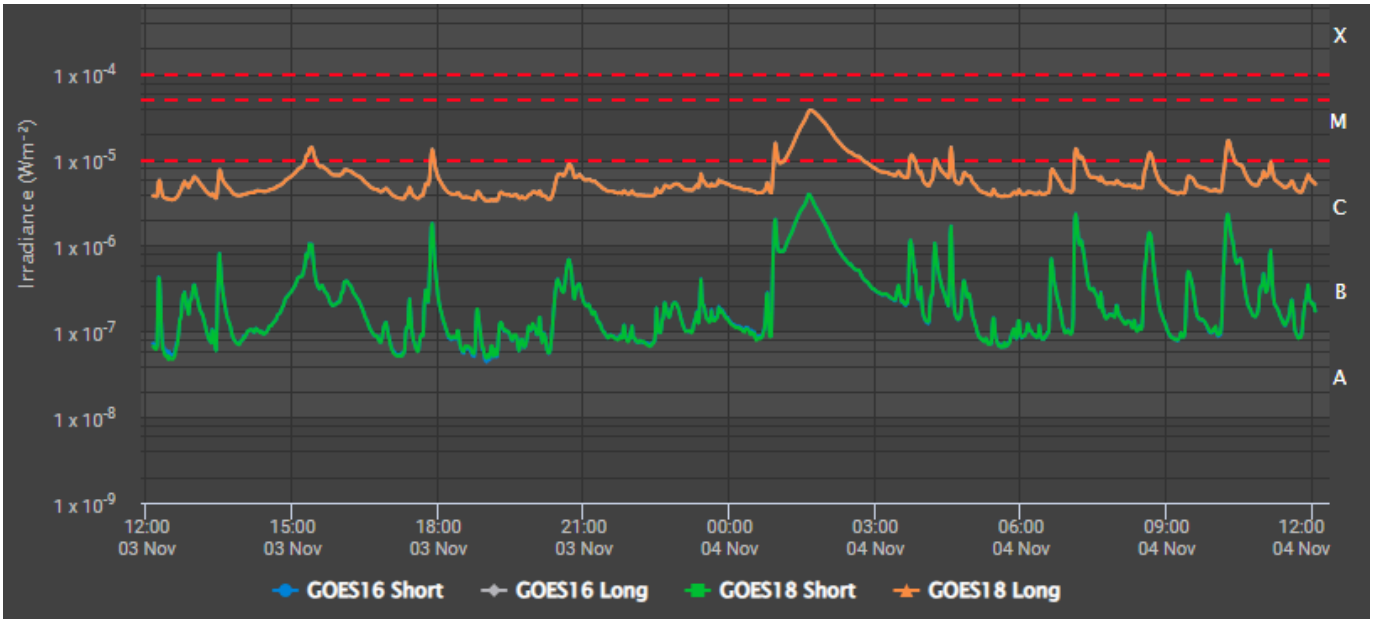
Figure 3: GOES-16 & -18 X-ray flux for the past 24hrs



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Solar Radiation Storms (High Energy Protons)

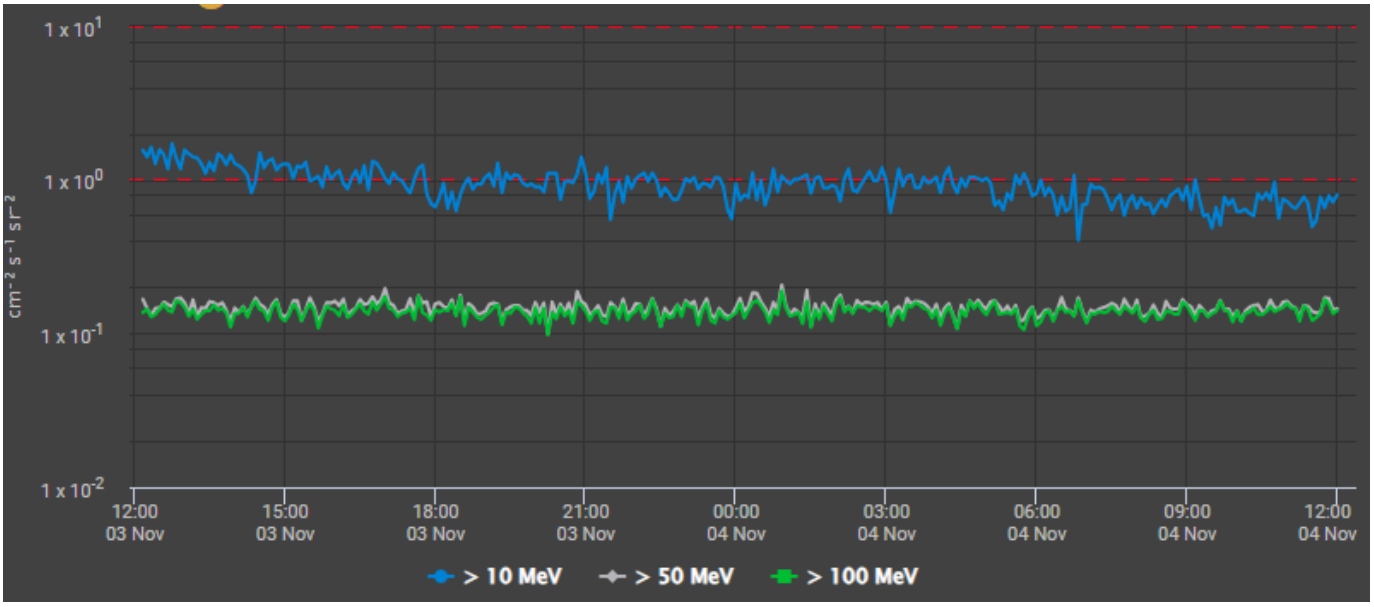
The recently elevated high energy proton flux at GOES-18 over previous days has now fallen below the S1 Minor Radiation storm level and is expected to decline towards background through Days 1-2 (04-05 Nov) in the absence of any further enhancement.

Further enhancements do remain possible however, with the potential for notable flares from a number of the sunspots on the disc. This includes the cluster of regions in the western disc, all of which will remain in potentially geo-effective positions through the period even as some spots round the western limb. The proton risk associated with AR3878 will also only increase into the period as this region transits west, although only limited proton response has been diagnosed from the recent significant flares from this region.

Overall there is a persistent chance of further proton enhancement though the period, reducing slightly through the latter half as conditions likely continue to ease in the absence of further enhancement.

Radiation Storms Probability (Exceedance)	Level ($cm^{-2}sr^{-1}s^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	25	25	20	20
Very Active	**≥ S3 ***	No	5	5	5	5
* S3 ≥ 10 MeV ≥ 1000 pfu and/or 50 MeV ≥ 10pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: GOES-18 Proton flux over the past 24hrs



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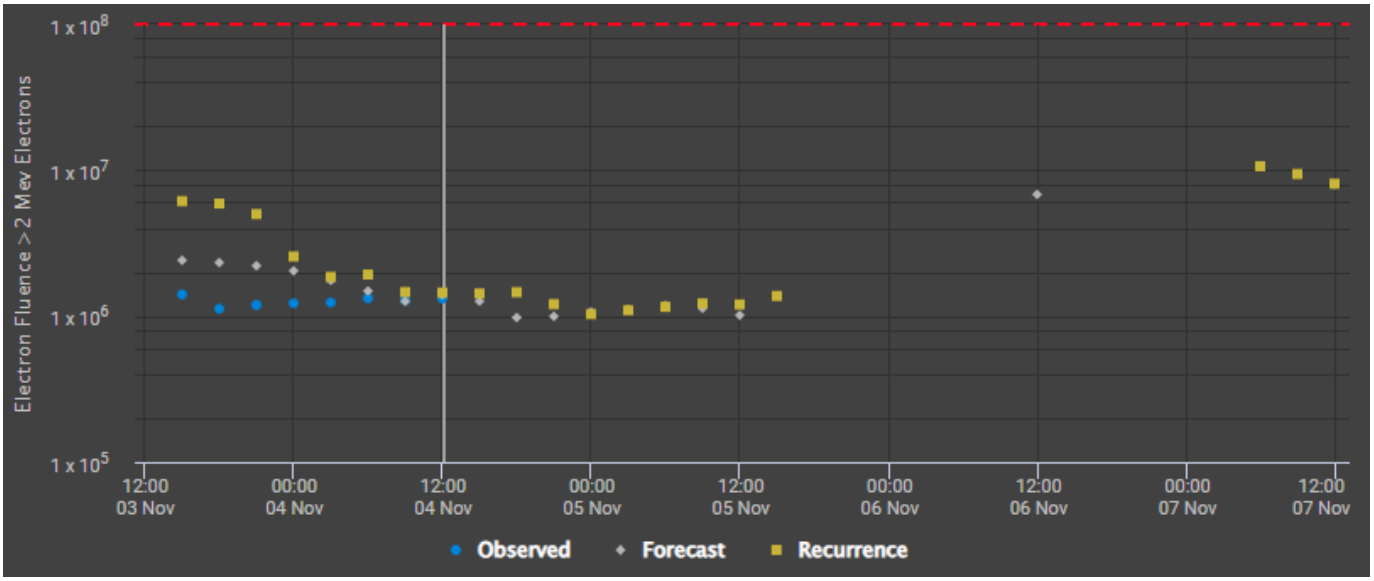
High Energy Electrons (≥ 2MeV)

High energy electron flux (greater than 2MeV) as observed by GOES16 is currently at background and expected to persist mostly at this level, with only brief spells of moderate enhancement expected. A more significant connection to coronal hole fast winds than we are currently seeing could see the electron belts charged up over the next couple of days, with the belts then expanding later in the period, and electron flux levels rising perhaps to more moderate to high levels.

The associated 24-hour fluence is currently expected to remain well below Active throughout the period however, with the MOSWOC REFM forecast though to be providing reasonable guidance.

GEO Electron Environment	Level ($cm^{-2}sr^{-1}$ day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ 1×10^{8}	No	1	1	1	1
Very Active	≥ 2 MeV ≥ 1×10^{9}	No	1	1	1	1

Figure 5: MOSWOC REFM model, providing reasonable guidance currently



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